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Does sports activity improve health? Representative evidence using proximity to sports facilities as an instrument

Marc Brechot, Stephan Nüesch and Egon Franck

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University of Zurich, Plattenstrasse 14, CH-8053 Zurich,
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Contact Details

Marc Brechot

University of Zurich

Department of Business Administration

marc.brechot@business.uzh.ch

Stephan Nüesch

University of Münster

Chair of Business Management

stephan.nueesch@wiwi.uni-muenster.de

Egon Franck

University of Zurich

Department of Business Administration

egon.franck@business.uzh.ch

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Abstract

Using representative and geocoded data from the Swiss Household Panel and the Swiss Business Census, we estimate the effect of sports activity on health care utilization and health. Because sports activity is likely correlated with unobserved determinants of health care utilization and health, we use the number of sports facilities within 6 miles of the individual's residence as an instrument. We find that doing sports at least once a week significantly reduces the number of doctor visits, overweight and sleeping problems. The magnitudes of these effects are larger in the IV estimations than in OLS estimations, which are biased toward zero due to reporting errors in sports activity and an omitted variable bias. To know the magnitudes of the causal effects is crucial for any kind of cost-benefit analysis of promoting individual sports activity.

Keywords: sports activity; health care utilization; health; instrumental variable; proximity to sports facilities

JEL classification: I10; I12; H51; C26

1 Introduction

Physical inactivity is widely acknowledged as a global health problem in the 21st century. The proportion of inactive people is rising in many countries, creating risks for individual health, health care utilization and ultimately public health care costs (World Health Organization, 2010). Therefore, exercise and intervention programs that target an increase of individual physical activity are a recurring theme on the agenda of policy makers around the world (Heath et al., 2012). Such programs are supported by a rich body of cross-sectional epidemiological research showing a positive correlation between physical inactivity and a wide variety of detrimental health outcomes such as obesity, hypertension, osteoporosis, osteoarthritis, diabetes mellitus, colon and breast cancer, depression (see e.g. Warburton, Nicol, & Bredin, 2006; Katzmarzyk & Janssen, 2004) and health care utilization such as doctor consultations and hospital days (see e.g. Manning, Keeler, Newhouse, Sloss, & Wasserman, 1991; Haapanen-Niemi, Miilunpalo, Vuori, Pasanen, & Oja, 1999; Katzmarzyk, Gledhill, & Shephard, 2000; Sari, 2009).

However, because physical activity is an endogenous choice variable and therefore likely correlated with unobservable confounders, evidence from cross-sectional studies cannot be given a causal interpretation. For example, health-conscious people with a high level of body awareness may be more active. At the same time, such people also tend to get more health screenings (e.g. cancer screening or general health checks) and tend to visit the doctor more often (Ioannou, Chapko, & Dominitz, 2003; Hansell, Sherman, & Mechanic, 1991). Another potential confounder is a person's healthy or unhealthy lifestyle, for example their nutrition, sleeping behaviour or personal hygiene. A healthy lifestyle tends to be positively correlated with sports activity and negatively correlates with health issues and health care utilization.

Randomized control trials can potentially solve the endogeneity issue by assigning individuals to treatment groups with an intervention program or to control groups. Field experiments on physical activity and health-related outcomes have been conducted with

Texaco employees (Baun, Bemacki, & Tsai, 1986), employees of insurance companies (Shephard, 1992), Bank of America retirees (Leigh et al., 1992), or Johnson and Johnson employees (Ozminkowski et al., 2002). But because samples in these studies are small and derived from very specific settings, results from these experimental studies are hardly generalizable to the rest of the population (Sari, 2009).

In this study, we take advantage of two hitherto uncombined datasets from Switzerland to address both the endogeneity and the external reliability issues. We combine representative survey data on individual sports activity and health-related outcomes with data on sports infrastructure. Employing geographic coordinates of individual home addresses and units of sports facilities, we use the availability of sports facilities to predict sports activity. Geographic proximity to sports facilities is an ideal instrument because it increases sports activity, and the supply of sports facilities is exogenous to unobservable factors affecting health and health care utilization (at the individual level).

Our identification strategy is related to the work of Huang and Humphreys (2012), who use proximity to sports facilities to identify the effect of sports activity on happiness, and Bowblis and McHone (2013) and Grabowski, Feng, Hirth, Rahman, and Mor (2013), who use proximity to nursing homes with different ownership to test the influence of nursing ownership on care quality. We are the first to use geographic proximity to sports facilities as an instrument in the context of sports activity and health.

We find that doing sports at least once a week reduces the number of doctor visits and the number of hospital days. The magnitudes of these effects are larger in our estimations using instrumental variable (IV) models than in those using non-IV models and in related correlational studies (e.g. Sari, 2009; Haapanen-Niemi et al., 1999; Keeler, Manning, Newhouse, Sloss, & Wasserman, 1989). When we use proximity to sports facilities as an instrument for sports activity, individuals who do sports at least once a week have 23% of the doctor visits and 43% of the number of hospital days of inactive individuals (although the latter effect is not statistically significant due to the high standard errors in the IV-model).

Because self-reported sports activity information likely suffers from misreporting (e.g. Ferrari, Friedenreich, & Matthews, 2007), we argue that non-IV estimates on the effect of sports activity on health care utilization are biased towards zero. IV models provide a solution to the errors-in-variables problem and the resulting attenuation bias. In addition, the non-IV models may also underestimate the effects of sports activity on health care utilization due to a positive omitted variable bias. For example, individuals who do sports at least once a week may be more health-conscious than non-active individuals, and (unobserved) health-consciousness increases health care utilization, holding everything else equal (Ioannou et al., 2003; Hansell et al., 1991).

In order to examine the channels through which sports activity influences health care utilization, we estimate how sports activity affects four specific health outcomes: overweight, sleeping problems, headaches, and back problems. Our IV results confirm findings from previous correlational studies showing that sports activity significantly reduces overweight (see e.g. Janssen et al., 2005; Ortega, Ruiz, & Sjöström, 2007; Patrick et al., 2004) and sleeping problems (see e.g. Atkinson & Davenne, 2007).

While the effects of sports activity on headaches and back problems are also negative and significant in the non-IV models, they become statistically insignificant when instrumenting sports activity by proximity to sports facilities. This indicates a reverse causation issue in the non-IV models. Using the proximity to sports facilities as an instrument of sports activity addresses the reverse causation issue as headaches and back problems decrease the propensity to do sports. Notably, the insignificant effect of sports activity on back problems is in line with comprehensive evidence from a recent medical review study (Sitthipornvorakul, Janwantanakul, Purepong, Pensri, & van der Beek, 2011).

The remainder of this paper is structured as follows: In section 2, we outline our data and the empirical strategy. In section 3, we explain our estimation method. In section 4, we present the results, and section 5 concludes.

2 Data and empirical strategy

The empirical problems of disentangling the relationship between individual sports activity and health-related outcomes are manifest. On the one hand, if one relies on observable field data from representative samples, self-selection is a major issue because sports activity is an endogenous choice variable. Failure to account for this source of endogeneity will bias any estimation of an effect from individual sports activity (see e.g. Heckman, 1979). On the other hand, if one relies on quasi-experimental clinical trials that allow for randomization of fitness program participants and control groups, findings are hardly representative for general populations (Sari, 2009).

To consider both issues at once, we use representative field data on individual sports activity and health-related outcomes and address the self-selection problem by employing an instrumental variables strategy. We use variation in geographic proximity to sports facilities as an instrument for individual sports activity. The reasoning behind this strategy is that living close to sports facilities implies easier access to sports infrastructure (Huang & Humphreys, 2012) and reduces the "costs" of doing sports. Both monetary costs (in terms of transportation costs) and time costs (for travelling) indicate a positive relation between short distances to sports facilities and sports activity (see also the discussion in Felfe, Lechner, and Steinmayr (2011))

In this section, we first describe our data sources. Second, we discuss the dependent and independent variables that we investigate in our analysis and third, we present our instrumental variable.

2.1 Description of data sources

The data on sports activity, health and health care utilization is part of the tenth wave of the *Swiss Household Panel* (SHP) collected in 2008. A key advantage of SHP is that the sample includes a stratified random sample of households representing the resident population of Switzerland. Originally, the randomization of the sample was constructed under guidance of the Swiss *Federal Statistical Office* based on the major statistical regions in Switzerland (for detailed information about the sample design, see Voorpostel et al., 2012). Overall, our sample comprises 6,872 individuals (aged 14 years and older) living in 4,166 distinct households. The data for these 6,872 individuals were collected using computer-assisted telephone interviews held from September 2008 to February 2009. The survey includes questions on individual sports activity, health and health care utilization, and other socioeconomic characteristics[1].

To measure the availability of sport facilities for the individuals in the SHP sample, we obtained additional data from the Swiss *Business Census* for the year 2008. The *Business Census* is a mandatory survey of workplaces and businesses in Switzerland and aims to collect full data on their economic activity, the number of persons employed, and their exact geographic location[2]. The data is collected by means of paper questionnaires and online questionnaires under the responsibility of the Swiss *Federal Statistical Office*. The reference day for the 2008 *Business Census* was September 30, 2008.

A specific classification code of economic activity (called *NOGA* codes in the Swiss context) marks sport facilities. Under *NOGA* code 931100, facilities for indoor or outdoor sports are recorded. This includes football grounds, athletics grounds, swimming pools, golf courses and so on. In total about one thousand sport facilities are recorded by *NOGA* code 931100. An important advantage is the geo-coding of each sports facility via Swiss grid coordinates. These coordinates pinpoint the location of a sports facility within a few meters of the building's midpoint and allow us to draw a very precise map of the geographic distribution of sports facilities in Switzerland.

In the standard version of SHP, the most accurate geographic information on an individual's home location is the canton of residence. However, to obtain an accurate link

[1]After dropping a small number of individuals that did not respond correctly to all of the items of our analysis, the final sample consists of 6,558 out of the original 6,872 SHP individuals.

[2]Participation in the survey is compulsory for all targeted workplaces and businesses. However, there is a minimum of 20 hours of weekly work for a business unit to be targeted by the survey. Therefore, the data does not include very small sports facilities that do not employ at least one person with an engagement of 50% or more.

between SHP individuals and sports facilities, we needed more detailed geographic information. We gratefully acknowledge SHP's provision of exact home addresses for each individual in the data set, after we signed a special confidentiality agreement. The provided home addresses included information on the community, zip code, street name and street number[3]. We used the public webpage http://tools.retorte.ch/map/ to transform these address data into Swiss grid coordinates. Using home address Swiss grid coordinates, we are able to pinpoint linear distances between the residence of an individual and all sports facilities obtained from the Swiss *Business Census* with a precision of a few meters.

2.2 Health and health care utilization measures

The SHP survey includes two items on health care utilization. In a question on doctor visits, respondents were asked: "In the last 12 months, how many times have you consulted a doctor?" Doctor visits at home are explicitly included in these numbers (through the interviewers' introduction of the question), whereas visits to a dentist do not count. In a similar question on hospital services, respondents were asked: "In the last 12 months, how many days have you spent in a hospital or specialized clinic, not including spas or wellness cures?" Outcomes for both items are non-negative, integer count variables.

To examine the potential channels through which sports activity affects health care utilization, we also aim to test the effect of sports activity on various health outcomes. Following the questions included in the SHP survey, we consider four specific indicators for health problems. Most notably, we include a discrete indicator for overweight, which has been argued to be both a consequence of physical inactivity due to a disrupted energy balance (Katzmarzyk & Janssen, 2004) *and* a risk factor for chronic health problems (Dixon, 2010) and health care utilization (Cawley & Meyerhoefer, 2012). To identify

[3]SHP was not able to provide the complete address for 43 individuals (either no street name was provided or the provided street name was not identifiable). In these cases, we were not able to obtain Swiss grid coordinates. Hence, we were not able to match these individuals with the sports infrastructure data and were forced to exclude them from our sample.

overweight individuals, we converted height and weight data into a discrete measure of overweight via WHO Body Mass Index guidelines (World Health Organization, 2000).

Other specific indicators available from the SHP survey include regular suffering from sleeping problems, headaches, and back problems. They were obtained from questions of the type: "During the last 4 weeks, have you suffered from one of the following disorders or health problems?" While respondents were allowed to choose between three categories (not at all, somewhat, very much), we used a binary yes/no coding that only treats serious incidences (i.e. "very much") as a specific health problem.

2.3 Sports activity measure

To identify individual sports activity, we draw on an SHP question from the leisure time section. Respondents were asked: "How frequently do you practice an individual or team sport (for example fitness, jogging, football, volley ball, tennis)?" Respondents were free to provide any description of their sports activity level but interviewers were supposed to help respondents provide a reasonable answer if necessary. Afterwards, interviewers had to assign the responses to five different levels of sports activity: every day, at least once a week, at least once a month, less then once a month, never. Large proportions of the respondents reported doing sports activities at least once a week (57.9%) or not at all (25.6%). Each of the other three categories contained only a small proportion of the respondents: 6.9% reported daily sports activity, and 9.5% reported some occasional sports activity but not every week (at least once a month: 7.1%; less than once a month: 2.4%). To allow for a straighforward interpretation of the results, we aggregate the five categories of sports activity into the discrete measure of sports activity "at least once a week".[4]

[4]The dichotomization avoids any functional form assumptions for different subgroup effects (Lechner, 2009). Of course, one could easily argue for counting occasional sports activity as being active. For example, Lechner (2009) has chosen a definition that separates less then monthly sports participation (inactive) and monthly sports participation (active). To test for the impact of our particular definition, we additionally estimated all our models with cut-off points that treat occasional sports participation as "active". The results are virtually unaffected by the alternative cut-off points (see Appendix, Table A1).

2.4 Instrumental variable: Proximity to sports facilities

To mimic randomization of individuals' selection into sports activity, we use geographic proximity to sports facilities as an instrument. We define *proximity* to sports facilities as the number of sports facilities within a certain radius surrounding an individual's home address. The key issue in the construction of the measure is to identify an appropriate radius up to which sports facilities potentially affect a person's sport activity.

Table 1 shows summary statistics for the different distance boundaries and the F-statistics for the measures in first-stage regressions. The F-test of instrument exclusion is significant for all radii and is above the threshold-level of 10 (see Staiger and Stock (1997)) for radii between 3 and 10 miles. Due to the highest explanatory power in the first-stage regression, we use the number of sports facilities within 6 miles as instrument in the main specification. The use of 6 miles as distance boundary is also consistent with an empirical finding by Pawlowski, Breuer, Wicker, and Poupaux (2009) that people are (on average) willing to spend a maximum of 28 minutes to travel to sport facilities. However, our results are widely robust to the use of alternative distance boundaries to construct the instrument (see Table A2 in the Appendix)[5]. An illustrative example of our approach is shown in Figure 1 for an individual living in central Switzerland.

Of course, valid instruments not only have to be powerful. The exogeneity condition of IV regressions requires that instruments are not correlated with the error term in the second stage (see e.g. Stock & Watson, 2003; Murray, 2006). In our analysis, this means that proximity to sports facilities must be uncorrelated with health-related outcomes, except through variables that are included in the equation. Hence, we have to diligently check the control variables. More specifically, we have to control for factors that correlate with both proximity to sports facilities and health/health care utilization. Brunekreef and

[5]The only findings that do not hold for all boundaries between 4 and 8 miles are related to the effect of sports activity on sleeping problems and overweight. While the coefficients remain negative throughout all specifications, the effects become marginally insignificant for the 4-mile boundary for overweight and the for 7- and 8-mile boundaries for sleeping problems. This indicates that reduced power in the first stage significantly affects the precision in the second stage.

Table 1
Comparison of different measures of *proximity* to sports facilities

Distance boundaries	mean	s.d.	First-stage F-test of excluded instrument
Sports facilities within 1 mile	1.68	2.30	F=2.71
Sports facilities within 2 miles	5.01	6.41	F=8.19
Sports facilities within 3 miles	9.13	10.88	F=19.15
Sports facilities within 4 miles	13.70	15.43	F=24.48
Sports facilities within 5 miles	18.45	19.56	F=30.68
Sports facilities within 6 miles	23.41	23.44	F=33.71
Sports facilities within 7 miles	28.67	27.66	F=27.51
Sports facilities within 8 miles	34.37	31.97	F=30.26
Sports facilities within 9 miles	40.52	36.39	F=29.02
Sports facilities within 10 miles	47.14	40.78	F=21.66
Number of households	4,016		
Number of individuals	6,558		

Notes: Data on sports facilities is drawn from the 2008 Swiss *Business Census* and is linked to the home addresses of SHP individuals. The F-test of excluded instrument reflects the power of our measure of proximity to sports facilities in equation (1). All models control for age, gender, marital status, education, household income, household with children, community typology, and population density.

Holgate (2002), Passchier-Vermeer and Passchier (2000) and Boes, Nüesch, and Stillman (2013) show that living in urban areas is likely to affect individual health status through noise pollution, air pollution and other factors. At the same time, urban areas with a high population density naturally provide a higher number of sports facilities. Therefore, we include two measures of residential area characteristics for each individual home address in our analysis. These are the community typology (following the official SHP categorization) and population density per square mile[6].

In addition, we include a large set of demographic and socio-economic control variables that may reflect individual differences in the availability of sports facilities and that have been widely used in studies on residential choice and in studies on health-related outcomes (see e.g. Winkelmann, 2004; Sari, 2009; Lee & Waddell, 2010; Kim, Pagliara, & Preston, 2005). These include age, sex, marital status, education, household earnings[7],

[6]The data on home-address specific population density is obtained from the 1990, 2000, and 2010 Swiss *Population Census* through extrapolation for the year 2008. The *Population Census* counts all individuals in each and every hectare in Switzerland. We linked this hectare-based population data to the SHP households via Swiss grid coordinates. Population size is converted into population density per square mile based on the same distance boundary that is used for our proximity to sports facility measure (i.e. 6 miles in the main specification).

[7]Unfortunately, 7.9% of the individuals did not provide valid data for household earnings. In order to keep these observations in the sample, we classify respondents into five different income groups, one of which is "unknown".

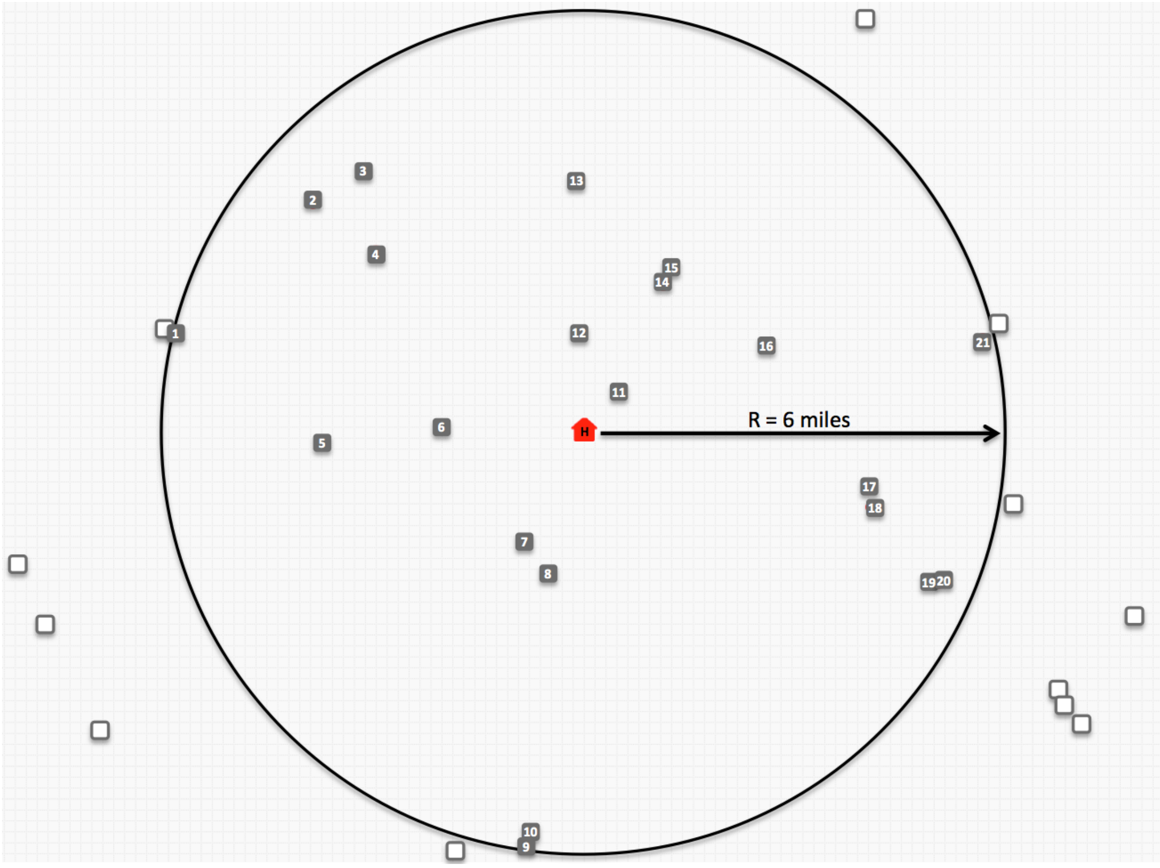

Figure 1

Measure of *proximity* to sport facilities

Notes: The figure depicts a distance boundary of 6 miles for counting the number of sports facilities surrounding an individual's home address. Filled squares represent units that are included in the count measure (i.e. 21) and empty squares represent units that are treated as "out of reach".

and household with children.

Nevertheless, one must always be cautious with regard to the exogeneity condition of IV models because it is impossible to prove the null hypothesis of no correlation between instruments and the (unobserved) error term in the second stage. If more sporty people intentionally choose to live close to sports facilities, our IV estimates could still be biased (irrespective of our included controls). However, research on residential choice suggests that non-work travel preferences do not play an important role in neighbourhood selection and that considerations of accessibility are mainly driven by commuting to work (see the discussion in Chatman (2009)). For example, Lee, Waddell, Wang, and Pendyala (2010) estimated that commuting to work is more than ten times as important as the shopping opportunities in the neighbourhood for residential choice. Following this view, we believe that unobserved residential sorting based on proximity to sports facilities is not a major concern for our estimation strategy.

3 Estimation method

Because previous research has shown that non-linear IV models are potentially biased when estimated with standard two-stage least squares methods (see the discussion in Terza, Bradford, & Dismuke, 2008), we estimate a two-stage residual inclusion (2SRI) model. 2SRI is basically a version of the control function approach developed by Wooldridge (2002, 2014). Rather than replacing the endogenous explanatory variable with the first-stage predictors, the equation in the second stage includes the first-stage residuals as an additional regressor.

In the first stage of our 2SRI procedure, we identify the probability of an individual to participate in sports activities by the following model framework:

$$\mathit{SportsActivity}_i = f(\mathit{Proximity}_i, X_i, \omega_i) \tag{1}$$

where i indexes the individual and ω denotes the random regression error term. The dependent variable $\mathit{SportsActivity}_i$ is a dummy variable that is 1 for individuals that participate in sports activities at least once a week and 0 for individuals that do not. $\mathit{Proximity}_i$ captures the number of sports facilities within 6 miles of the home address of individual i. The vector of covariates X_i captures a set of home address-specific residential area controls and observed individual background variables. The function $f(\cdot)$ will be a linear function in our main specification. Estimating the first stage by a linear probability model is the safest way when the underlying error distribution is unknown (Angrist, 2001) and allows us to compute the F-statistic of the excluded instrument.[8]

[8]As a sensitive check, our 2SRI estimation was repeated using a Probit model in the first stage. The results, presented in Table A3 of the Appendix, are widely unaffected by the use of a Probit specification.

In the second stage, we model our outcome variables as a function of the endogenous dummy for weekly sports activity, the set of covariates, and the saved residuals of the regression in the first stage. The model framework is:

$$H_i = f(SportsActivity_i, X_i, \hat{\omega}_i, \nu_i) \tag{2}$$

where i again indexes the individual and ν_i denotes the random regression error term. X_i denotes the vector of covariates from the first stage. The dependent variable H_i represents our set of health-related outcomes variables. The main explanatory variable of interest is $SportsActivity_i$. $\hat{\omega}_i$ denotes the residuals from the first-stage estimation and substitutes for any unobserved confounders that might be correlated with both $SportsActivity_i$ and H_i.

For all binary outcome variables, we estimate the second stage using a a linear probability model.[9] For count outcome variables, we use negative binomial MLE.[10] To account for the fact that the second stage of our 2SRI model includes a regressor imputed from first-stage estimates, the coefficients' standard errors in the second stage are bootstrapped (Carpio, Wohlgenant, & Boonsaeng, 2008; Huang & Humphreys, 2012). A total of B = 999 replications were used to generate the standard errors, confidence intervals and hypothesis tests.[11]

The only finding that does not hold for a Probit first stage is related to the effect of sports activity on overweight. While the coefficient remains strongly negative, the effect becomes marginally insignificant.

[9] Additionally, we report Probit estimations for our binary outcome variables in the Appendix (see column (3) in Table A3). The results are widely unaffected by the alternative specification of the second stage.

[10] We choose the negative binomial MLE over Poisson estimation because the number of doctor visits and the number of days in hospital are both overdispersed (Wooldridge, 2002).

[11] Since results using bootstrapped standard errors are not fully replicable by other researchers, we also estimated all our models with conventional (Huber-White) "robust" standard errors. We obtained very similar standard errors in both approaches, which resulted in identical inference for all outcome measures. Full results for estimations with conventional standard errors are available from the authors upon request.

4 Results

4.1 Summary statistics

Descriptive statistics for all our variables are shown in Table 2. Individuals reported on average 3.5 doctor visits and 0.9 hospital days within the 12-month period. There is a very long right tail of the response distribution[12] for both measures but the proportion of reported zeros (indicating no use at all) is significantly higher for hospital use than doctor use (85.3% compared to 24.9%). The high share of hospital non-users also explains the low number of average hospital treatment days. 35.7% of the individuals are overweight while about 8% to 10% of the individuals report suffering from one of the other three health issues (sleeping problems, headaches, and back problems).

65.3% of the individuals in our sample do sports at least once a week. Compared to existing studies using samples from other countries, the proportion of active people in our sample is in the middle of the range of the observed numbers. While Huang and Humphreys (2012) found 76.5% of the individuals in a US sample to be physically active, other studies from Canada and Germany found only about 50% (Sari, 2009; Humphreys, McLeod, & Ruseski, 2014) or 40% (Lechner, 2009; Sari, 2014) to be active individuals. Our instrument of *Number of sports facilities within 6 miles* has a mean of 23.42. This indicates that individuals in our sample have on average 23.4 sports facilities within 6 miles of their place of residence. The measure has substantial variation as the number of sports facilities ranges from zero to 106 with a standard deviation of 23.40.

The average age in the sample is 46.2 years. A little under half the sample is male (44.4%) and a little over half the sample is married (53.8%). Individual education splits into five categories with shares between 10% and 36%. The high share of apprenticeships (36.4%) reflects the importance of occupational training in the Swiss education

[12] To avoid problems with outliers (some individuals reported up to 200 doctor visits or 327 hospital days), we "winsorized" the responses by setting outlying values to the 99th percentile. However, all our results are very robust to use of the original (non-winsorized) reported values. We only observe a slight increase in the size of the marginal effects using the original counts.

Table 2
Summary statistics

Independent variables	mean	s.d.	min	max
Health care utilization				
Number of doctor visits	3.485	5.121	0	30
Number of hospital days	0.876	3.347	0	25
Health				
Overweight	0.357	0.479	0	1
Sleeping problems	0.085	0.279	0	1
Headaches	0.077	0.266	0	1
Back problems	0.100	0.300	0	1
Individual sports activity				
Weekly sports activity	0.653	0.476	0	1
Instrumental variable				
Number of sports facilities within 6 miles	23.415	23.440	0	106
Demographics and socio-economic controls				
Age	46.12	18.36	14	96
Male	0.445	0.497	0	1
Married	0.537	0.499	0	1
Education: Compulsory	0.228	0.420	0	1
Education: Apprenticeship	0.363	0.481	0	1
Education: University-entrance diploma	0.100	0.299	0	1
Education: Post-apprenticeship diploma	0.161	0.368	0	1
Education: University degree	0.148	0.355	0	1
Household income: <50,001 Swiss Francs	0.111	0.314	0	1
Household income: 50,001- 100,000 Swiss Francs	0.325	0.469	0	1
Household income: 100,001 - 150,000 Swiss Francs	0.280	0.449	0	1
Household income: >150,000 Swiss Francs	0.206	0.405	0	1
Household income: unknown	0.078	0.268	0	1
Household with children	0.372	0.483	0	1
Residential area				
Community typology: Centres	0.269	0.444	0	1
Community typology: Suburban	0.306	0.461	0	1
Community typology: Wealthy	0.038	0.191	0	1
Community typology: Periurban	0.114	0.318	0	1
Community typology: Touristic	0.023	0.149	0	1
Community typology: Industrial	0.088	0.284	0	1
Community typology: Rural	0.079	0.270	0	1
Community typology: Agricultural	0.084	0.277	0	1
Population density per square mile	1,575.0	1,370.2	9	5,737
Number of households	4,016			
Number of individuals	6,558			

Notes: Data on sports facilities is drawn from the 2008 Swiss *Business Census*. Data on population density are interpolated from the 1990, 2000, and 2010 Swiss *Population Census*. All other variables are directly drawn from the 2008 SHP survey. *Number of doctor visits* and *Number of hospital days* are "winsorized" to the 99th percentile.

system. In terms of household income, individuals are divided into four income levels and a non-response group, with most individuals (32.6%) living in households with an income between 50,000 and 100,000 Swiss Francs (reflecting roughly $48,000 - $96,000 based on the currency rate of 2008). Most of the individuals live in urban centres (26.8%) or in a suburban type of community (30.5%). The average population density per square mile is 1,575.4.

4.2 First-stage results

The first-stage results show that the number of sports facilities within 6 miles significantly increases weekly sports activity (see Table 3). The F-statistic for excluding the number of sports facilities in the regression is 33.71, indicating that our instrument easily passes the conventional test for power in the first stage (see Staiger & Stock, 1997). This implies that proximity to sports facilities strongly predicts individual sports activity.

The estimates for the additional demographic and socio-economic controls are largely consistent with previous research on the determinants of individual sports activity (see e.g. Huang & Humphreys, 2012; Farrell & Shields, 2002). The likelihood of sports activity strongly increases with education and household income and decreases with age. Interestingly, we observe males to be less active then women in the Swiss context, while an earlier study from England showed the opposite relationship between gender and sports activity (Farrell & Shields, 2002). With regard to the residential area, we find that sports activity is higher in suburban areas than in centres and that sports activity decreases with a higher population density.

4.3 Regression results

Table 4 presents the estimates of the effect of weekly sports activity on health care utilization (Panel A) and health (Panel B). To consider the endogeneity of sports activity, we estimate IV models using 2SRI. These models include the control variables from the

Table 3
First-stage results

Independent variables	Dependent variable Weekly sports activity (1)
Number of sports facilities within 6 miles	0.006*** (0.001)
Age	-0.004*** (0.0004)
Male	-0.025** (0.012)
Married	-0.009 (0.015)
Education: Compulsory	Ref. group
Education: Apprenticeship	0.030* (0.016)
Education: University-entrance diploma	0.036* (0.022)
Education: Post-apprenticeship diploma	0.080*** (0.020)
Education: University degree	0.108*** (0.020)
Household income: $<$50,001 Swiss Francs	Ref. group
Household income: 50,001- 100,000 Swiss Francs	0.084*** (0.022)
Household income: 100,001 - 150,000 Swiss Francs	0.153*** (0.024)
Household income: $>$150,000 Swiss Francs	0.197*** (0.025)
Household income: unknown	0.135*** (0.029)
Household with children	-0.009 (0.014)
Community typology: Centres	Ref. group
Community typology: Suburban	0.043*** (0.015)
Community typology: Wealthy	0.080*** (0.030)
Community typology: Periurban	0.057*** (0.020)
Community typology: Touristic	-0.020 (0.042)
Community typology: Industrial	-0.022 (0.024)
Community typology: Rural	0.017 (0.025)
Community typology: Agricultural	0.017 (0.024)
Population density per square mile/100	-0.010*** (0.002)
F-test of excluded instrument	33.71
Number of individuals	6,558

Notes: In column (1) OLS estimates for equation (1) are displayed. The dependent variable is a dummy variable that takes a value of 1 for individuals that do sports at least once a week and a value of 0 otherwise. All estimations also included a constant (not reported). Robust standard errors are given in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

first-stage regression (see Table 3) and the first-stage residuals as an additional regressor. For the purpose of comparison, Table 4 also presents non-IV models that exclude the first-stage residuals. Column (1) reports the estimated coefficients of weekly sports activity from the non-IV models and column (2) reports the estimated coefficients of weekly sports activity using the 2SRI approach.

Because raw coefficient estimates from negative binomials are difficult to interpret (Dávalos, Fang, & French, 2012), we also report the incidence rate ratio (IRR) for models with count outcomes (i.e. the health care utilization models in Panel A). An IRR represents the difference in the rate of the count outcome predicted by the model when switching sports activity from zero to one while all other variables are kept constant at their means. A value greater than one indicates that sports activity increases the outcome, and a value between zero and one indicates that sports activity decreases the outcome. The further away from one a value is, the stronger the effect becomes.

Table 4
Regression results

	Effects of weekly sports activity	
	Non-IV (1)	IV (2SRI) (2)
A. Health care utilization outcomes:		
Number of doctor visits	-0.132*** [0.876] (0.039)	-1.475*** [0.229] (0.531)
Number of hospital days	-0.317*** [0.728] (0.098)	-0.840 [0.432] (1.438)
B. Health outcomes:		
Overweight	-0.102*** (0.012)	-0.280* (0.165)
Sleeping problems	-0.031*** (0.008)	-0.230** (0.104)
Headaches	-0.023*** (0.007)	0.045 (0.100)
Back problems	-0.045*** (0.008)	0.097 (0.117)
F-test of excluded instrument in the first-stage	-	33.71
Number of individuals	6,558	6,558

Notes: Non-IV estimates for weekly sports activity are displayed in column (1) with white robust standard errors in parentheses. IV estimates for weekly sports activity are displayed in column (2) with bootstrapped standard errors (999 reps) in parentheses. In Panel A, negative binomial MLE is used and incidence rate ratios are displayed in brackets. In Panel B, OLS estimates are displayed. All models control for age, gender, marital status, education, household income, household with kids, community typology, and population density. All estimations also included a constant (not reported). are given . *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The results from the non-IV models show that sports activity significantly reduces the number of doctor visits, the number of hospital days, overweight, sleeping problems, headaches, and back problems. Controlling for the endogeneity of sports activity with the 2SRI approach results in different findings. Column (2), Panel A also shows that sports activity significantly reduces the number of doctor visits but the magnitude of the effect is much larger when controlling for the endogeneity of sports activity. We observe an IRR of 23% in the IV model compared to an IRR of 88% in the non-IV model. The greater distance of the IRR from one in the IV model indicates a bias toward zero in the non-IV results. Similarly, we find that sports activity reduces the number of hospital days at a higher rate when using an IV model than when using a non-IV model (IRR of 43% compared to IRR 73%). However, the effect of sports activity on hospital days is not statistically significant in the IV model due to the high standard errors.

Column (2), Panel B shows that sports activity significantly reduces the probability of suffering from overweight and sleeping problems, by 28% and 23%, respectively. Again, the magnitudes of the effects are larger when controlling for the endogeneity of sports activity, indicating a bias toward zero in the non-IV results. In contrast, the effects of sports activity on headaches and back problems become positive and statistically insignificant in the IV model. Thus the effects from the non-IV models seem to be spurious, because the effects from sports activity on headaches and back problems disappear once the endogeneity of sports activity is controlled for.

5 Discussion

This paper uses a representative sample of the Swiss population and geocoded data on sports facilities, sports activity, health and health care utilization to estimate the causal effect of sports activity on health and health care utilization. Unlike previous correlational studies, we use an instrument for sports activity, namely the number of sports facilities within 6 miles of the individual's place of residence. We find that sports activity significantly reduces doctor visits, overweight and sleeping problems. Though the same trends are seen when we use an estimation without the instrumental variable and have been seen in previous correlational studies, the magnitudes of these effects are considerably larger in our IV estimation. Our results may be useful for estimating the cost-effectiveness of sports facilities to encourage sports activity and thereby decrease health problems and health care utilization.

Two reasons may explain why our IV estimates on health care utilization, overweight and sleeping problems are higher than the effects reported in the previous literature: First, our IV method addresses measurement error in the self-reported sports activity variable (see Ferrari et al. (2007) for reporting errors of physical activity). Reporting errors in sports activity lead to an underestimation of the effect. Second, previous estimates of sports activity on health care utilization may have suffered from an omitted variable bias. For example, sporty people may be more health-conscious, which increases health care utilization and perceived health problems even in the absence of obvious health issues. For example, previous evidence has shown that higher levels of body awareness are associated with more patient-initiated visits to HMO and patient-initiated contacts with hospital emergency rooms among older adults (Hansell et al., 1991). Also, health-conscious subgroups of the population are more likely to participate in screening-related health care utilization (Ioannou et al., 2003).

The endogeneity of sports activity is also important when estimating its effects on back problems and headaches. The correlational estimation that only considers a set of control variables associates sports activity with a small but significant reduction in the frequency of back problems and headaches, whereas the IV estimates associate sports activity with a small and statistically insignificant increase in the frequency of these health issues. The non-IV results seem to be negatively biased and are likely to suffer from a reverse causation issue. Individuals with back problems and headaches (probably more than individuals with sleeping problems and overweight) tend to reduce sports activity.

This paper has some limitations. The first limitation concerns the validity of the instrument *proximity to sports facilities*. Our identifying assumption is that the proximity to sports facilities is uncorrelated with unobserved determinants of health and health care utilization. We argue that this assumption is plausible for three reasons: First, because sports facilities are provided by communities and not by individuals, reverse causality can be excluded. Second, community-level variables help to control for potential confounders that are likely to be correlated with both the number of sports facilities and health and health care utilization. Third, it is well-known that individuals self-select into neighborhoods based on housing prices, housing quality, commuter distance, school quality and/or environmental factors such as noise. However, non-work related travel distances (such as proximity to sports facilities) are found to play only a negligible role in selecting a neighbourhood to live in (Lee et al., 2010; Chatman, 2009). Nevertheless, as residential neighborhoods are not randomly assigned, we cannot completely rule out that unobserved health determinants could influence residential sorting into neighborhoods with few or many sports facilities. Future papers should conduct field experiments with representative samples out of which a random subgroup is incentivized to participate in sports.

A second limitation is that we use a cross-sectional data set. While panel data on sports facilities, individual sports activity and health outcomes are available, the variation of the number of sports facilities over time is too low to have any statistical power in first-stage regressions. Therefore, the application of an instrumental variables strategy in fixed-effects models is not feasible (see Table A4 in the Appendix).

A third limitation is that the data on sports activity and health outcomes is self-reported. Although the IV method helps to correct for reporting errors in the sports activity measure, it does not eliminate reporting errors in the outcome variables. A fourth limitation of our study is that we have data on sports activity only at the consolidated level for all different types of sports and at the ordinal level for the frequency of sports.

Ideally, we would have data on subgroups of sports (e.g. football, tennis, jogging) and hours of weekly participation that would allow us to estimate marginal effects of additional hours in different types of sports.

Despite these limitations, this paper makes an important contribution by providing first IV-estimates on the effects of sports activity on health and health care utilization based on a representative sample. For doctor visits, overweight, and sleeping problems, the magnitudes of the causal effects are higher than indicated by correlations between sports activity and health, indicating that measurement errors and omitted variables bias can lead to an underestimation of the associations in correlational studies.

Appendix

Table A1
Robustness check: Alternative cut-offs for sports activity

	IV effects of different levels of sports activity		
	>Weekly (Main specification) (1)	>Monthly (2)	>Never (3)
A. Health care utilization outcomes:			
Number of doctor visits	-1.475*** [0.229]	-1.537*** [0.215]	-1.591*** [0.204]
	(0.531)	(0.550)	(0.554)
Number of hospital days	-0.840 [0.432]	-0.938 [0.391]	-0.909 [0.403]
	(1.438)	(1.535)	(1.515)
B. Health outcomes:			
Overweight	-0.280*	-0.292*	-0.300*
	(0.165)	(0.168)	(0.175)
Sleeping problems	-0.230**	-0.240**	-0.247**
	(0.104)	(0.112)	(0.115)
Headaches	0.045	0.047	0.048
	(0.100)	(0.100)	(0.105)
Back problems	0.097	0.102	0.105
	(0.117)	(0.124)	(0.128)
F-test of excluded instrument in the first-stage	33.71	35.62	36.32
Number of individuals	6,558	6,558	6,558

Notes: 2SRI estimates for weekly sports activity are displayed with bootstrapped standard errors (999 reps) in parentheses. In Panel A, negative binomial MLE is used and incidence rate ratios are displayed in brackets. In Panel B, OLS estimates are displayed. Column (1) to (3) refer to different sports activity thresholds for individuals to be categorized as "active". All models control for age, gender, marital status, education, household income, household with children, community typology, and population density. All estimations also included a constant (not reported). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A2

Robustness check: Using a range of distance boundaries for proximity to sports facilities

	IV effects of weekly sports activity using different boundaries for proximity to sports facilities				
	4 miles (1)	5 miles (2)	6 miles (Main specification) (3)	7 miles (4)	8 miles (5)
A. Health care utilization outcomes:					
Number of doctor visits	-1.487** [0.226]	-1.764*** [0.171]	-1.475*** [0.229]	-1.346** [0.260]	-1.469*** [0.230]
	(0.630)	(0.566)	(0.531)	(0.561)	(0.559)
Number of hospital days	-0.502 [0.605]	-0.691 [0.501]	-0.840 [0.432]	-1.510 [0.221]	-1.257 [0.284]
	(1.613)	(1.528)	(1.438)	(1.577)	(0.154)
B. Health outcomes:					
Overweight	-0.211	-0.290*	-0.280*	-0.340**	-0.354*
	(0.193)	(0.174)	(0.165)	(0.180)	(0.183)
Sleeping problems	-0.334***	-0.321***	-0.230**	-0.178	-0.180
	(0.126)	(0.111)	(0.104)	(0.118)	(0.114)
Headaches	-0.007	0.059	0.045	0.056	0.067
	(0.112)	(0.101)	(0.100)	(0.107)	(0.104)
Back problems	0.029	0.026	0.097	0.148	0.129
	(0.135)	(0.124)	(0.117)	(0.126)	(0.124)
F-test of excluded instrument in the first-stage	24.48	30.68	33.71	27.51	30.26
Instrument coefficient in the first-stage	0.006***	0.006***	0.006***	0.005***	0.005***
Number of sports facilities within distance boundary	13.70	18.45	23.41	28.67	34.37
Number of individuals	6,558	6,558	6,558	6,558	6,558

Notes: 2SRI estimates for weekly sports activity are displayed and bootstrapped standard errors (999 reps) are given in parentheses. In Panel A, negative binomial MLE is used and incidence rate ratios are displayed in brackets. In Panel B, OLS estimates are displayed. Column (1) to (5) refer to different distance boundaries for proximity to sports facilities. All models control for age, gender, marital status, education, household income, household with children, community typology, and population density. All estimations also included a constant (not reported). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A3
Robustness checks: Alternative estimation approach

	IV effects of weekly sports activity		
	First stage: LPM	First stage: Probit	
	Second stage: LPM/Negbin (1) (Main specification)	Second stage: LPM/Negbin (2)	Second stage: Probit/Negbin (3)
A. Health care utilization outcomes:			
Number of doctor visits	-1.475*** [0.229]	-1.553*** [0.212]	-1.553*** [0.212]
	(0.531)	(0.512)	(0.512)
Number of hospital days	-0.840 [0.432]	-0.957 [0.384]	-0.957 [0.384]
	(1.438)	(1.444)	(1.444)
B. Health outcomes:			
Overweight	-0.280*	-0.253	-0.667 [-0.250]
	(0.165)	(0.160)	(0.483)
Sleeping problems	-0.230**	-0.213**	-1.284* [-0.252]
	(0.104)	(0.107)	(0.659)
Headaches	0.045	0.090	0.726 [0.083]
	(0.100)	(0.097)	(0.710)
Back problems	0.097	0.094	0.515 [0.076]
	(0.117)	(0.117)	(0.630)
Number of individuals	6,558	6,558	6,558

Notes: 2SRI estimates for weekly sports activity are displayed and bootstrapped standard errors (999 reps) are given in parentheses. In column (1), included residuals are obtained from a linear probability first-stage regression. In column (2), included residuals are obtained from a Probit first-stage regression. In column (3), included residuals are obtained from a Probit first-stage regression and Probit estimates are displayed for the binary outcomes in Panel B (with marginal effects at the mean in brackets). For all models in Panel A, negative binomial MLE is used and incidence rate ratios are displayed in brackets. All models control for age, gender, marital status, education, household income, household with children, community typology, and population density. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A4
First-stage fixed-effects results

Independent variables	Dependent variable: Weekly sports activity (1)
Number of sports facilities within 6 miles	-0.0001
	(0.0006)
Demographic and socio-economic control variables	Yes
Residential area control variables	Yes
Individual fixed-effects	Yes
F-test of excluded instrument in the first-stage	0.01
Number of observations	65,909
Number of individuals	14,574

Notes: The estimation included 10 years of individual panel data from 1999 to 2008. The data on sports facilities is drawn and interpolated from the 1998, 2001, 2005, and 2008 Swiss *Business Census*. Data on population density is drawn and interpolated from the 1990, 2000, and 2010 Swiss *Population Census*. All other variables are directly drawn from the SHP surveys 1999 - 2008. OLS estimates for equation (1) including individual fixed-effects are displayed. The dependent variable is a dummy variable that takes a value of 1 for individuals that do sports at least once a week and a value of 0 otherwise. The estimation also included a constant (not reported). *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

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